

COMBUSTION

Project Fact Sheet



VERY LOW EMISSIONS: VORTEX INERTIAL STAGED AIR (VISTa) BURNER

BENEFITS

- Provides a burner with NO_x emissions less than 9 ppm at three percent oxygen
- Provides a burner with carbon monoxide (CO) less than 50 ppm at three percent oxygen
- Low Levels of Unburned Hydrocarbons and Air Toxics
- High Turndown Range

APPLICATIONS

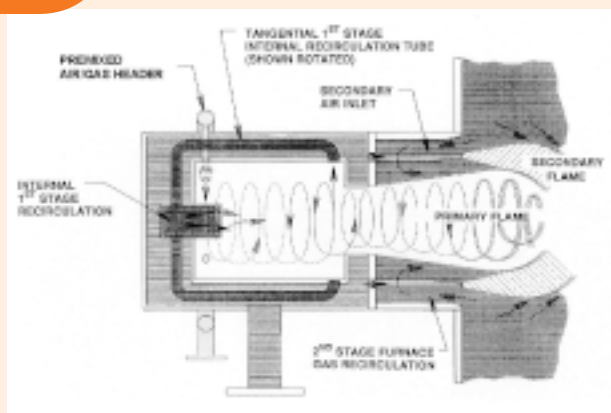
This combustor can be applied in most commercial and industrial boilers which annually consume well over 6 quadrillion British thermal units (Btu). It will be introduced first to the petroleum industry as one of several combustor alternatives offered by the John Zink Company.

VISTa LOW NITROGEN OXIDES (NO_x) COMBUSTOR RESEARCH WILL PRODUCE AN ECONOMICAL ULTRA-LOW EMISSIONS COMBUSTOR WITH NO_x LESS THAN 9 PARTS PER MILLION BY VOLUME (PPMV)

The VISTa combustor concept uses two combustion stages. The purpose of the first stage is to convert natural gas to hydrogen and carbon monoxide, which do not form NO_x , via the "prompt" mechanism. In the first stage, natural gas and part of the combustion air are premixed and tangentially admitted at high velocity into the combustion chamber through multiple ports. Using the radial pressure difference created by the vortex, part of the combustion products are removed through tangential openings, cooled, and returned to the combustor axially at a center opening via multiple recirculation tubes. Recirculation and cooling of the first stage combustion products are important aspects of the VISTa technology. Hydrocarbon and nitrogen-bound compounds, which contribute to prompt NO_x formation, can be minimized by controlling the stoichiometry, temperature, and residence time. The cooled, recirculated gases reduce the oxygen concentration and temperature in the combustor, thereby reducing thermal NO_x formation.

The cooled, first stage combustion gases enter the main combustion chamber where secondary air is introduced axially through an annular opening around the burner periphery. The secondary air stream is introduced in a manner that aspirates furnace gases into the annular space between the first stage combustion products and secondary air stream. This works to lower both the temperature and oxygen concentration in the secondary flame zone, thereby minimizing the final thermal NO_x formation.

THE VISTa COMBUSTOR



Concept of the VISTa Ultra-Low NO_x Combustor.



Project Description

Goal: Bring to market an economically attractive, very low emissions combustor with NO_x production of less than 9 ppmv and CO emissions of less than 50 ppmv -- both at three percent oxygen (O₂) -- while maintaining high efficiency and ease of operation and maintenance.

The VISTa combustor addresses both prompt and thermal NO_x production in an air-staged combustor design. It reduces prompt NO_x by partially converting thoroughly premixed natural gas fuel and air in the first stage of the combustor to CO and hydrogen (H₂). By operating the first stage of the combustor at optimum conditions, natural gas can be converted to species that will not contribute to the formation of prompt NO_x. The inertial combustion system is ideal for this purpose, because it promotes very stable combustion over a wide range of stoichiometry and firing rates, and aids in the conversion of the fuel.

The VISTa combustor reduces thermal NO_x production by utilizing advanced aerodynamic principles to provide high internal flue gas recirculation (FGR) in each of the combustion stages without resorting to conventional external flue gas recirculation approaches. This translates into improved efficiency and reduced maintenance and operating expenses.

Progress and Milestones

- Laboratory testing of three prototype VISTa combustors with nominal thermal inputs of 0.25, 3.0, and 6.0 million (mm) Btu per hour has demonstrated the technical viability of the VISTa concept as being capable of achieving the desired NO_x and CO emission levels:
 - As scale-up has progressed with each of these combustors, design modifications have been implemented with the aid of computational fluid dynamic (CFD) modeling using Fluent, a product of Fluent, Inc.
 - Through this parallel effort, verification of the computational model with actual performance test data is providing the technology understanding necessary for a scale-up to 30 to 60 mm Btu per hour levels
- Testing to date has demonstrated nitrogen oxide (NO) production in the first stage of less than 2 ppmv and stable operation at levels of 2.5 to 5.5 mm Btu per hour:
 - NO_x production in the second stage is the next optimization target
 - NO_x production with the current second stage is in the mid-range of 30 ppmv with CO emissions of less than 20 ppmv
- As the project approaches the conclusion of the development testing at the 4 to 6 mm Btu per hour scale, the development team is preparing for a 30 mm Btu per hour scale-up and test, which will be followed by a 60 mm Btu per hour scale-up test and industrial demonstration.



PROJECT PARTNERS

Thermo Power Corporation
Waltham, MA

John Zink, a Koch Industries Company
Tulsa, OK

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Gideon Varga
Office of Industrial Technologies
Phone: (202) 586-0082
Fax: (202) 586-7114
gideon.varga@ee.doe.gov
<http://www.oit.doe.gov/combustion>

Please send any comments,
questions, or suggestions to
webmaster.oit@ee.doe.gov.

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Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, D.C. 20585



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